RAMSPOST User's Guide

(RAMSPOST Version 6)

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Purpose and Intended Audience

This document presents basic informations on how to use the RAMPOST. In a first version, it is expected that this document evolves as the BRAMS community makes contributions to RAMSPOST and to this documentation.

BRAMS (Brazilian Regional Atmospheric Modeling System) has its root on RAMS (Regional Atmospheric Modeling System) and simulates atmospheric circulations on limited geographical area. RAMSPOST and BRAMS are maintained and supported by the BRAMS team at CPTEC (`http://www.cptec.inpe.br`). Maintenance and support should be obtained by mailing a message to `brams@cptec.inpe.br`. For further information, visit BRAMS site at `http://www.cptec.inpe.br/brams`.

BRAMS use one of two terrains following coordinate system: Shaved Eta and Sigma-Z. This document is about the RAMSPOST version for Sigma-Z coordinate system. Informations about the coordinate system in: `http://www.atmet.com/html/docs/documentation.shtml`.

The next sections bring informations about the RAMSPOST, how to download, compile and run RAMSPOST, RAMSPOST's confirguration and a list of variables that is possible to visualize.

About RAMSPOST

Basically, RAMSPOST (RAMS POSTprocessing) is a package for generating graphical representations and reformatting RAMS model output. BRAMS is a regional modeling system derived from RAMS (`http://www.atmet.com`) and his output files have many atmospheric informations (like wind velocity vector components, atmospheric pressure, temperature etc), geographical informations (as topography) and others more. Informations about BRAMS can be found in `http://www.cptec.inpe.br/brams`.

Once the BRAMS ends the run, a set of files named "analysis" are availables in a format called VFM. VFM is a file format created by ATMET (`http://www.atmet.com`) for RAMS input and output files format. It allows to select a subset of variables for visualization. Many variables must to be calculated from BRAMS output variables (in section XX there is a list of variables that can be visualized and the respectives variables from BRAMS output files used to generate them). RAMSPOST allows to define a region range to visualize the chosen variables. RAMSPOST reads the "analysis" output file generated in a simulation and it generates an output file in the GRADS' format input file for posterior graphical vizualization. The Grid Analysis and Display System (GrADS) is an interactive desktop tool that is used for easy access, manipulation, and visualization of earth science data (`http://grads.iges.org/grads/grads.html`).

Download and run RAMSPOST

If you did the download of BRAMS' First Time Users Version (`http://www.cptec.inpe.br/brams/brams4.0/f_time.shtml`), a copy of RAMSPOST compiled and ready to run is available in the directory called RAMSPOST60. Its execution is done by a script that runs the BRAMS for all the stages: preprocessing, wheather forecast, postprocessing and visualization. In postprocessing stage the RAMSPOST runs over the BRAMS output files. After this, GRADS use the files generated by RAMSPOST for visualize some variables.

In other case, it is possible to download the RAMSPOST from BRAMS' Webpage:

`http://www.cptec.inpe.br/brams/utilities.shtml`

There is a tarball with the source code and pre-defined scripts for some compilers: G95 Gnu FORTRAN Compiler and Portland Group FORTRAN Compiler.

Download the file ramspost60.tar.gz and save it. You can uncompress this file in the same directory of BRAMS. Use the following command:

```
tar -xzvf ramspost60.tar.gz
```

After this you will have a diretory called `Ramspost60` with the following files and directories:

Files:

```
Makefile_50.g95
Makefile_50.pgi
README
anheader.f90
comp.sh
include_ramspost_g95.mk
include_ramspost_pgi.mk
ramspost.inp
ramspost_A.f90
ramspost_B.f90
ramspost_C.f90
ramspost_D.f90
```

Directories:

```
LIB
include
```

Note that is possible to use other directory since the path of the analysis files (BRAMS output) is defined in `ramspost.inp` file. The `ramspost.inp` structure and RAMSPOST configuration are discussed in following sections.

A resume of this section was included in README file.

The RAMSPOST needs some BRAMS' subroutines that work with the reading of VFM files. In this way, before compiling the RAMPOST the path of the BRAMS code must be defined. This is done in file `paths.mk` inside the directory LIB. Edit this file and change the RAMS_ROOT variable with the correct BRAMS path. This variable is in beginning of the file:

```
#RAMS root directory
RAMS_ROOT=/path/to/BRAMS  (Change to the correct path)
```

Now, is possible to compile the RAMSPOST. Return to the Ramspost60 directory and run the `comp.sh` script:

./`comp.sh`

The following message will appear:

```
Set a compiler!

Compiling:
- G95        : ./comp.sh g95
- Portland   : ./comp.sh pgi

Cleanning:
- G95        : ./comp.sh g95 clean
- Portland:  : ./comp.sh pgi clean
 Remember to set source BRAMS path in ./LIB/paths.mk file
```

This message shows different ways to run the script. In this point use one of the compiling options.

```
./comp.sh g95
```

or

```
./comp.sh pgi
```

With this, an executable binary of RAMSPOST application is ready to use:

```
ramspost_60-g95
```

or

```
ramspost_60-pgi
```

RAMSPOST configuration parameters

The `rampost.inp` is the file that governs the RAMSPOST run. It is a namelist file that contains all the main definitions for post processing the analysis files and to generate the GRADS' input files. In this section, only the main variables of the `rampost.inp` will be discribed.

The first variable to define is the FPREFIX. It defines location and prefix of the analysis files (BRAMS'output). In BRAMS First Time User version, the FPREFIX has the following value:

```
FPREFIX = '../A/anal-A-',
```

With this definition, the RAMSPOST will work over all the files that have the prefix `'anal-A-'` stored in `./A` directory. If the analysis files of your interest have other name or they are stored in other directory, change the FPREFIX value. If only one file will be visualized, write its complete name.

It may be the case that two BRAMS runs with distinct configurations (dates, domain, etc) store analysis files (BRAMS' output) at the same directory. In such a case, it is important to change the prefix of the analysis files in each run. This prevents the RAMSPOST to interpolate the results from different simulations and generate strange results. Remember: change the analysis prefix in all RAMSIN files and in ramspost.inp file.

The variables NVP and VP indicate the amount of the variables to be visualized and which are the variable. See this example from the First Time User:

```
NVP = 20,
VP = 'totpcp',
'sst',
'topo',
'vtype',
'stext',
'smoist',
'w',
'u',
'v',
'tempc',
'theta',
'rh',
'rv',
'pcprate',
'acccon',
'h',
'le',
'rlong',
```

```
'rshort',
'rlongup',
```

In this case, twenty variables were defined to visualize. Each variable has a physical mean and it is possible to know the meaning of each one with a help of the RAMSPOST output file with the .ctl extension, like is shown bellow:

```
vars 23
totpcp      0 99  - RAMS : total resolved precip      [mm liq ]
sst         0 99  - RAMS : water temperature          [C ]
topo        0 99  - RAMS : topo                       [m ]
vtype1      0 99  - RAMS : vegetation class: patch # 1 [# ]
vtype2      0 99  - RAMS : vegetation class: patch # 2 [# ]
stext1      9 99  - RAMS : soil twxture: patch # 1    [ ]
stext2      9 99  - RAMS : soil twxture: patch # 2    [ ]
smoist1     9 99  - RAMS : soil moisture: patch # 1   [m3/m3 ]
smoist2     9 99  - RAMS : soil moisture: patch # 2   [m3/m3 ]
w          30 99 - RAMS : w                          [m/s ]
u          30 99 - RAMS : u                          [m/s ]
v          30 99 - RAMS : v                          [m/s ]
tempc      30 99 - RAMS : temperature                [C ]
theta      30 99 - RAMS : potential temp             [K ]
rh         30 99 - RAMS : relative humidity          [pct ]
rv         30 99 - RAMS : vapor mix ratio            [g/kg ]
pcprate     0 99  - RAMS : resolved precip rate       [mm/hr ]
acccon      0 99  - RAMS : accum convective pcp       [mm ]
h           0 99  - RAMS : sfc sens heat flx          [W/m2 ]
le          0 99  - RAMS : sfc lat heat flx           [W/m2 ]
rlong       0 99  - RAMS : rlong                      [W/m2 ]
rshort      0 99  - RAMS : rshort                     [W/m2 ]
rlongup     0 99  - RAMS : rlongup                    [W/m2 ]
endvars
```

Some variable names like `vtype` and `stext` generate more than one field to be visualized. That is why rampost changes the initial variable count (20 at `rampost.inp`) into (23 at `.ctl` file).

There are many variables that can be selected for visualization. The next section has a relation of them. Note that GRADS will not visualize all the variables as the variables signed with “patch #1” in the list above.

It is important to note that if the NVP value is smaller then the amount of variables included in VP, only the first NVP-th variables will work.

It is not possible to use the NVP with larger values than the amount of variables listed in VP. When this occours RAMSPOST retunrs an error.

The GPREFIX variable defines the prefix for the RAMSPOST output files. GPREFIX indicates GRADS file PREFIX. In BRAMS First Time Users Version, GPREFIX is defines as:

```
GPREFIX = 'result',
```

The following variables define the range of visualization in grads. Note that the BRAMS works over a limited área defined in RAMSIN namelist file. The RAMSPOST allows to define an area for visualization inside the area defined in BRAMS. In this way, the variables `LATI`, `LATF` define the initial and final latitude and `LONI`, `LONF` define the initial and final longitude of the visualization. Usually, these variables are defined with values that cover the entire world, as showed bellow. With this, RAMSPOST will work over any simulation area of the BRAMS. More information about the definition of simulation area in BRAMS FIRST TIME USERS GUIDE:

```
http://www.cptec.inpe.br/brams/brams4.0/f_time_document.shtml
```

In default `ramspost.inp` the limits of visualization are defined as:

```
LATI = -90., -90., -90.,
LATF = +90., +90., +90.,
LONI = -180., -180., -180.,
LONF = +180., +180., +180.,
```

Note that there are three values for each variable. This is done for BRAMS simulations with nested grids. The ramspost takes the same order of the BRAMS simulations for nested grids. If only one grid was used in BRAMS execution, only the first value will be used by RAMSPOST.

In BRAMS horizontal grid uses a polar-stereographic projection. Pole of the projection is rotated to an area near the center of the domain. Then, when the area of simulation is near the poles, there are a distortion of the images because the use of this projection scheme. To minimize the distortion, `ramspost.inp` has a variable called `PROJ`:

```
PROJ = 'YES'
```

This option define that the RAMSPOST must to correct distortions caused by the projection when the area of simulation is "near" the poles.

The next variables say respect to vertical levels of the grid and data results. The variable ZLEVMAX defines the amount of vertical levels for each BRAMS grid (if nested grids were used). These values must be the same as defined in RAMSIN namelist. In the example,

```
ZLEVMAX = 33, 33, 1, 27,
```

`ZLEVMAX` defines the amount of vertical level to four nested grids. The sequence of values to each grid is the same as defined in RAMSIN. If the amount of vertical levels in RAMSPOST if smaller then the amount of vertical level defined in RAMSIN, only the same amount of level will be visualized. When the ZLEVELMAX value is bigger then

the amount of vertical level of RAMSIN definition, the amount of vertical level is determined by RAMSIN.

The variable IPRESSLEV defines the type of vertical level will be used for visualization. Three values are possible for this variable:

0 (zero) indicates original vertical level. This option makes the RAMSPOST uses the vertical level as defined in BRAMS' original grid (RAMSIM)

1 (one) indicates vertical levels based in atmospheric pressure level. This option uses some constants atmospheric pressure value to define vertical level.

2 (two) indicates vertical levels based in altitude levels. This option uses some constant altitude values to define vertical level.

If the variable `IPRESSLEV` was setted in either 1 or 2, the variable INPLEVS defines the amount of vertical levels will be used in visualization. Remember that if IPRESSLEV was setted in 0, the original vertical levels will be used.

Once the `INPLEVS` was defined, the next step is to define the constant values either for atmospheric pressure or for altitude. To define the values for the atmospheric pressure and altitude it is enough to use the `IPLEV` variable. This variable is defined with a sequence of values that indicates either atmospheric pressure levels (`IPRESSLEV=1`) or altitude values (`IPRESSLEV=2`) for visualization of vertical levels. When the chosen level doesn't agree with the original grid vertical levels, RAMSPOST interpolate the original values to agree with the choosen vertical levels.

For example,

```
IPRESSLEV = 1,
INPLEVS = 8,
IPLEV = 1000, 925, 850, 700, 500, 300, 200, 100,
```

In this example, the vertical levels were defined for constant atmospheric pressure levels (`IPRESSLEV=1`). `INPLEVS` indicates that 8 levels will be used and `IPLEV` defines the atmospheric pressure values for vertical levels determination.

RAMSPOST variables for plotting

As said in previous section, RAMSPOST reads the analysis files generated by BRAMS and generate files to be visualized in GRADS. This section has the aim to describe the field names and the respective description needed to configure the RAMSPOST. The first column is the field name used in `ramspost.inp` file (`VP` variable value). The second column is the description of the field and in the third column are the variables from BRAMS analysis output that generate the field. Some fields are calculated from more then one model variable.

It is important to note that some variables can't work in RAMSPOST to either all BRAMS versions or RAMSPOST versions. For each new version (BRAMS and RAMSPOST), new variables can be added to this list once the news BRAMS version will bring new models and funcionalities. When some variables are not used in one version,

they will not appear in GRADS file generated by RAMSPOST and is possible that RAMPOST shows error messages.

3D Atmospheric Variables:

The following variables are defined on the 3D-atmospheric grid and may be plotted in either horizontal or vertical cross section. Obviously, many of these variables are dependent on which options were activated for a particular run.

3D Velocity and Vorticity Variables

Field Name	***Description[units]***	***Model Variables***
u	x-direction wind component [m/s]	UP
v	y-direction wind component [m/s]	VP
u_avg	eastward wind component averaged to T point [m/s]	UP, VP
v_avg	northward wind component averaged to T point [m/s]	UP, VP
zitheta	Height PBL [m -sigmaz]	THETA, RCP
ue	earth rotated eastward wind component [m/s]	UP, VP
ve	earth rotated northward wind component [m/s]	UP, VP
ue_avg	eastward wind component earth rotated and averaged to T point [m/s]	UP, VP
ve_avg	northward wind component earth rotated averaged to T point [m/s]	UP, VP
w	z-direction wind component [m/s]	WP
wcms	z-direction wind component [cm/s]	WP
w_avg	z-direction wind component averaged to T point [m/s]	WP
speed	horizontal wind speed averaged to T point [m/s]	UP, VP
speed_mph	horizontal wind speed averaged to T point [mph]	UP, VP
direction	horizontal wind direction averaged to T point [deg]	UP, VP
relvortx	x-component of relative vorticity [rad/s]	UP, VP, TOPT
relvorty	y-component of relative vorticity [rad/s]	UP, VP, TOPT

relvortz	z-component of relative vorticity [rad/s]	UP, VP, TOPT
absvortz	z-component of absolute vorticity [rad/s]	UP, VP, TOPT
potvortz	z-component of potential vorticity [rad/s]	UP, VP, TOPT, THETA
horiz_div	horizontal divergence [s^-1]	WP

3D Thermodynamic Properties of Air

Field Name	***Description[units]***	***Model Variables***
pi	Exner function [J/(kg K)]	PI
press	pressure [mb]	PI
theta	potential temperature [K]	THETA
dn0	reference state density [kg/m^3]	TOPT
pi0	reference state Exner function [J/(kg K)]	TOPT
th0	reference state virtual potential temperature [K]	TOPT
pert_pressure	perturbation pressure [mb]	TOPT, PI
tempk	temperature [K]	THETA, PI
tempc	temperature [deg C]	THETA, PI
tempf	temperature [deg F]	THETA, PI
theta_e	equivalent potential temperature [K]	RV, THETA, PI
theta_v	virtual potential temperature [K]	THETA, PI

3D Moisture Mass Mixing Rations and Humidity

Field Name	***Description[units]***	***Model Variables***
rv	water vapor mixing ratio [g/kg]	RV
cloud	cloud water mixing ratio [g/kg]	RCP
rain	rain mixing ratio [g/kg]	RRP

Field Name	*Description[units]*	*Model Variables*
pristine	pristine ice mixing ratio [g/kg]	RPP
snow	snow mixing ratio [g/kg]	RSP
aggregates	aggregates mixing ratio [g/kg]	RAP
graupel	graupel mixing ratio [g/kg]	RPP
hail	hail mixing ratio [g/kg]	RHP
liquid	liquid water mixing ratio [g/kg]	RCP, RRP, RGP, Q6, RHP, Q7
ice	ice mixing ratio [g/kg]	RPP, RSP, RAP, RGP, Q6, RHP, Q7
total_cond	total condensate mixing ratio [g/kg]	RPP, RSP, RAP, RGP, Q6, RHP, Q7
rtotal	total water mixing ratio [g/kg]	RV, RCP, RRP, RPP, RSP, RAP, RGP, RHP
rtotal_orig	total water mixing ratio (original method) [g/kg]	RTP
dewptk	dew point temperature [K]	RV, PI, T
dewptf	dew point temperature [deg F]	RV, PI, THETA
dewptc	dew point temperature [deg C]	RV, PI, THETA
rh	relative humidity [percent]	RV, PI, THETA
clear_frac	clear sky [fraction]	RV, PI, THETA

3D Hydrometeor, CCN, CN, Dep N and nonhygroscopic Aerosol Numer Concentration

Field Name	*Description[units]*	*Model Variables*
cloud_concen_mg	cloud droplet number concentration [#/mg]	CCP
rain_concen_kg	rain number concentration [#/kg]	CRP

Field Name	*Description[units]*	*Model Variables*
pris_concen_kg	pristine ice number concentration [#/kg]	CPP
snow_concen_kg	snow number concentration [#/kg]	CSP
agg_concen_kg	aggregates number concentration [#/kg]	CAP
graup_concen_kg	graupel number concentration [#/kg]	CGP
hail_concen_kg	hail number concentration [#/kg]	CHP
cloud_concen_cm3	cloud droplet number concentration [#/cm^3]	CCP, TOPT
rain_concen_m3	rain number concentration [#/m^3]	CRP, TOPT
pris_concen_m3	pristine ice number concentration [#/m^3]	CPP, TOPT
snow_concen_m3	snow number concentration [#/m^3]	CSP, TOPT
agg_concen_m3	aggregates number concentration [#/m^3]	CAP, TOPT
graup_concen_m3	graupel number concentration [#/m^3]	CGP, TOPT
hail_concen_m3	hail number concentration [#/m^3]	CHP, TOPT
ccn_concen	CCN number concentration [#/mg]	CCCNP
ifn_conc	IFN number concentration [#/kg]	CIFNP

3D Hydrometeor Diameters

Field Name	*Description[units]*	*Model Variables*
cloud_diam	cloud droplet mean-mass diameter [microns]	RCP, CCP
rain_diam	rain mean-mass diameter [mm]	RRP, CRP
pris_diam	pristine ice mean-mass diameter [microns]	RPP, CPP
snow_diam	snow mean-mass diameter [mm]	RSP, CSP
agg_diam	aggregates mean-mass diameter [mm]	RAP, CAP
graup_diam	graupel mean-mass diameter [mm]	RGP, CGP
hail_diam	hail mean-mass diameter [mm]	RHP, CHP

3D Hydrometeor Temperature, Thermal Energy, Liquid Water Fraction

Field Name	*Description[units]*	*Model Variables*
q2	rain internal energy parameter [J/kg]	Q2
q6	graupel internal energy parameter [J/kg]	Q6
q7	hail internal energy parameter [J/kg]	Q7
rain_temp	rain temperature [deg C]	Q2
graup_temp	graupel temperature [deg C]	Q6
hail_temp	hail temperature [deg C]	Q7
rain_air_tempdif	rain-air temperature difference [K]	Q2, THETA, PI
graup_air_tempdf	graupel-air temperature difference [K]	Q6, THETA, PI
hail_air_tempdif	hail-air temperature difference [K]	Q7, THETA, PI
graup_fracliq	liquid fraction in graupel [ ]	Q6
hail_fracliq	liquid fraction in hail [ ]	Q7

3D Miscellaneous Fields

Field Name	*Description[units]*	*Model Variables*
geo	geopotential height [m]	TOPT
tke	turbulent kinetic energy [m^2/s^2]	TKEP
CO2	CO2 Concentration [ppm]	SCLP001
TKU0	CO tend concentration due convection transport	DUM3
cuthsh	Shallow convective heat hate [K/day]	THSRC_SH
curtsh	Shallow convective conv moisture rate [g/kg/day]	RTSRC_SH
cuthdp	Deep convective heat rate [K/day]	THSRC
curtdp	Deep convective moisture rate [g/kg/day]	RTSRC

Field Name	*Description[units]*	*Model Variables*
curidp	Convective liquid/ice rate [g/kg/day]	D3500
fthrd	Radiate heat rate [K/day]	FTHRD
khh	horizontal scalar mixing coefficient [m^2/s]	HKH
khv	vertical scalar mixing coefficient [m^2/s]	VKH

2D Atmospheric Variables

The following variables are defined as a function of horizontal coordinates only and may only be plotted in horizontal cross section.

Field Name	*Description[units]*	*Model Variables*
tempf2m	2-meter-height air temperature [deg F.]	UP, VP, THETA, TOPT, TGP, SCHAR, GSF, PI
tempc2m	2-meter-height air temperature [deg C.]	UP, VP, THETA, TOPT, TGP, SCHAR, GSF, PI
speed10m	10-meter-height wind speed [m/s]	UP, VP, THETA, TOPT, GSF, SCHAR, TGP
clear_frac	clear sky fraction [fraction]	RV, PI, THETA
cloud_frac	cloud cover fraction [fraction]	RV, PI, THETA
pbl_ht	planetary boundary layer height [m]	TOPT, TKE

2D Surface Precipitation

Field Name	*Description[units]*	*Model Variables*
accpr	surface accumulated rain [kg/m2]	ACCPR
accpp	surface accumulated pristine ice [kg/m2]	ACCPP
accps	surface accumulated snow [kg/m2]	ACCPS

Field Name	*Description[units]*	*Model Variables*
accpa	surface accumulated aggregates [kg/m2]	ACCPA
accpg	surface accumulated graupel [kg/m2]	ACCPG
accph	surface accumulated hail [kg/m2]	ACCPH
totpcp	surface accumulated resolved precipitation [mm liquid equivalent]	ACCPR, ACCPP, ACCPS, ACCPA, ACCPG, ACCPH
totpcp_in	surface accumulated resolved precipitation [inches liquid equivalent]	ACCPR, ACCPP, ACCPS, ACCPA, ACCPG, ACCPH
precip	surface accumulated resolved plus convective precipitation [mm liquid equivalent]	ACCPR, ACCPP, ACCPS, ACCPA, ACCPG, ACCPH, ACONPR
precip_in	surface accumulated resolved plus convective precipitation [inches liquid equivalent]	ACCPR, ACCPP, ACCPS, ACCPA, ACCPG, ACCPH, ACONPR
pcprr	surface precipitation rate of rain [mm/hr liquid equivalent]	PCPRR
pcprp	surface precipitation rate of pristine ice [mm/hr liquid equivalent]	PCPRP
psprs	surface precipitation rate of snow [mm/hr liquid equivalent]	PCPRS
pcpra	surface precipitation rate of aggregates [mm/hr liquid equivalent]	PCPRA
pcprg	surface precipitation rate of graupel [mm/hr liquid equivalent]	PCPRG
pcprh	surface precipitation rate of hail [mm/hr liquid	PCPRH

Field Name	***Description[units]***	***Model Variables***
	equivalent]	
pcpg	total surface precipitation falling this timestep [kg/m^2]	PCPG
qpcpg	total internal energy of surface precipitation falling this timestep [J/m2]	QPCPG
dpcpg	total added depth of surface precipitation falling this timestep [m]	DPCPG
pcprate	resolved surface precipitation [mm/hr liquid equivalent]	PCPRR, PCPRP, PCPRS,PCPRA, PCPRH, PCPRG, CONPRR
pcprate_in	resolved surface precipitation [inches/hr liquid equivalent]	PCPRR, PCPRP, PCPRS,PCPRA, PCPRH, PCPRG, CONPRR
precipr	resolved plus convective surface precipitation [mm/hr liquid equivalent]	PCPRR, PCPRP, PCPRS,PCPRA, PCPRH, PCPRG, CONPRR
precipr_in	resolved plus convective surface precipitation [inches/hr liquid equivalent]	PCPRR, PCPRP, PCPRS,PCPRA, PCPRH, PCPRG, CONPRR
conpcp	cumulus parameterization precipitation rate [mm/hr]	CONPRR
acccon	cumulus parameterization accumulated surface precipitation [mm]	CONPRR
cape	Cape [J/kg]	RV, PI, THETA
cine	Cine [J/kg]	RV, PI, THETA

Vertically-integrated atmospheric moisture

Field Name	*Description[units]*	*Model Variables*
vertint_rt	vertically-integrated total water mixing ratio [mm liquid equivalent]	TOPT, RCP, RRP, RPP, RSP, RAP, RGP, RHP, RV
vertint_cond	vertically-integrated total condensate mixing ratio [mm liquid equivalent]	TOPT, RCP, RRP, RPP, RSP, RAP, RGP, RHP

2D Surface Heat, Moisture, Momentum and Radiative Fluxes

Field Name	*Description[units]*	*Model Variables*
SFLUX_T	SFLUX_T [m]	SFLUX_T
SFLUX_R	SFLUX_R [m]	SFLUX_R
SFLUX_W	SFLUX_W [m]	SFLUX_W
uw	surface x-component momentum flux [m^2/s^2]	UW
vw	surface y-component momentum flux [m^2/s^2]	VW
wfz	surface y-component momentum flux [m^2/s^2]	WFZ
h	surface sensible heat flux [W/m^2]	SFLUX_T, TOPT
le	surface latent heat flux [W/m^2]	SFLUX_R, TOPT
etrans	evapotranspiration rate [mm/hr]	SFLUX_R, TOPT
etrans_in	evapotranspiration rate [in/hr]	SFLUX_R, TOPT
umom_flx	surface x-component momentum flux [Pa]	UW, TOPT
vmom_flx	surface y-component momentum flux [Pa]	VW, TOPT
wmom_flx	surface x-component momentum flux [Pa]	SFLUX_W, TOPT
bowen	Bowen ratio [ ]	SFLUX_T, SFLUX_R
rshort	incident surface flux of shortwave radiation [W/m^2]	RSHORT
rlong	incident surface flux of longwave radiation [W/m^2]	RLONG
rlongup	upward surface flux of longwave radiation [W/m^2]	RLONGUP

Field Name	*Description[units]*	*Model Variables*
albedt	grid-cell-averaged surface albedo [ ]	ALBEDT
qsc1	qsc1 [???]	DUM1

2D Topography and Geographic Values

Field Name	*Description[units]*	*Model Variables*
topo	topography height [m]	TOPT
topoa	topography height [m]	TOPA
lat	latitude [deg]	GLAT
lon	longitude [deg]	GLON

2D Miscellaneous Fields

Field Name	*Description[units]*	*Model Variables*
slp_OLD	sea level pressure [mb]	TOPT, PI, THETA
slp	sea level pressure [mb]	TOPT, PI, THETA
sfc_div	horizontal divergence at surface [1/s]	WP
sst	water temperature [deg C]	TGP

LEAF2 Variables Section

Field Name	*Description[units]*	*Model Variables*
ctprof	cloud top height [m]	???
land	land fractional area [ ]	PATCH_AREA
pfarea	patch fractional area [ ]	PATCH_AREA
soil_z0_ps, soil_z0_ps	soil roughness [m]	PATCH_AREA,

Field Name	***Description[units]***	***Model Variables***
		SOIL_Z0
vtype, veg_class_bp	vegetation class [#]	PATCH_AREA, LEAF_CLASS
ndvi	ndvi [#]	PATCH_AREA, VEG_NDVIC
qveg_class_p, qveg_class_bp	q vegetation class [#]	PATCH_AREA, DATQ_CLASS
vegfrac, veg_fracarea_ps	vegetation fractional area [ ]	PATCH_AREA, VEG_FRACAREA
lai, veg_lai_ps	green leaf area index [ ]	PATCH_AREA, VEG_LAI
tai, veg_tai_ps	total leaf area index [ ]	PATCH_AREA, VEG_TAI
net_z0_p, net_z0_ps	net roughness [m]	PATCH_AREA, NET_Z0
vegz0, veg_z0_ps	vegetation roughness [m]	PATCH_AREA, VEG_ROUGH
vegdisp, veg_disp_ps	vegetation displacement height [m]	PATCH_AREA, VEG_DISP
patch_wetind	patch wetness index [ ]	PATCH_AREA, WET_INDEX
snowlevels	number of snow levels [#]	PATCH_AREA, KSNOW
grnd_mixrat_p, grnd_mixrat_ps	ground mixing ratio [g/kg]	PATCH_AREA, SFC_RS
soil_mixrat_p, soil_mixrat_ps	soil mixing ratio [g/kg]	PATCH_AREA, SOIL_RS
veg_moist_p, veg_moist_ps	vegetation moisture [kg/m2]	PATCH_AREA, VEG_MOIST
canopy_mixrat_p,canopy_mixrat_ps	canopy mixing ratio	PATCH_AREA, CAN_RV
tveg, veg_temp_ps	vegetation temperature [C]	PATCH_AREA, VEG_TEMP
tcan, canopy_temp_ps	canopy temperature [C]	PATCH_AREA, CAN_TEMP

Sib-stuffs, itb, CO2 src.

Field Name	*Description[units]*	*Model Variables*
src_co2	CO2 flux [umol/m**2/sec]	SRC_CO2
CO2_SIB	CO2 Concentration [ppm]	SCLP001
pco2ap	CAS CO2 [Pa]	pco2ap
pco2m	REF LEVEL CO2 [Pa]	pco2m
rst	stomatal resistance [sec/meter]	rst
CO2	CO2 Concentration [ppm]	SCLP001, SCLR004

ITB New Diagnostics

Field Name	*Description[units]*	*Model Variables*
fss	sensible heat flux [W/m^2]	fss
fws	latent heat flux [kg H2O/m^2/sec]	fws
assimn	canopy net assimilation [mol/m^2/sec]	assimn
respg	ground respiration [mol/m^2/sec]	respg
rstfac1	stress factor 1-leaf to CAS humidity [(-)]	rstfac1
rstfac2	stress factor 2-soil moisture[(-)]	rstfac2
rstfac3	stress factor 3-temperature[(-)]	rstfac3
rstfac4	stress factor 4-combination of factors 1-3[(-)]	rstfac4
ect	canopy transpiration [W/m^2]	ect
eci	canopy interception evaporation [W/m^2]	eci
egi	ground interception evaporation [W/m^2]	egi
egs	top soil layer evaporation [W/m^2]	egs
hc	canopy sensible heat flux [W/m^2]	hc
hg	ground sensible heat flux [W/m^2]	hg
capac1	VEGETATION INTERCEPTION STORE	Capac1

Field Name	***Description[units]***	***Model Variables***
	[kg/m^2]	
capac2, capac2_ps	GROUND INTERCEPTION STORE [kg/m^2]	PATCH_AREA, capac2
ustar, ustar_ps	ustar [m/s]	PATCH_AREA, USTAR
tstar, tstar_ps	tstar [K]	PATCH_AREA, TSTAR
rstar, rstar_ps	rstar [kg/kg]	PATCH_AREA, RSTAR
hp, sens_heat_flux_ps	sfc sensible heat flx [W/m2]	PATCH_AREA, USTAR, TSTAR, TOPT
lep, lat_heat_flux_ps	sfc lat heat flx [W/m2]	PATCH_AREA, USTAR, RSTAR , TOPT
snow_depth_p, snow_depth_ps	snow depth [m]	PATCH_AREA, SNOW_DEPTH
snowcover_p, snowcover_ps	snowcover [kg/m2]	PATCH_AREA, SNOW_MOIST
sltex_p, sltex_bp	soil textural class [#]	PATCH_AREA, SOIL_TEXT
soilq, soilq_ps	soil q [J/m3]	PATCH_AREA, SOIL_ENERGY
tsoil, soil_temp_ps	soil/sea temp [C]	PATCH_AREA, SOIL_ENERGY, SOIL_WATER, SOIL_TEXT
5050_temp_ps, 5050_tempf_ps	5050 tempF [F]	PATCH_AREA, CAN_TEMP
smoist, SOIL_WATER_ps	soil moisture [m3/m3]	PATCH_AREA, SOIL_WATER
stext, stext_ps	soil texture [ ]	PATCH_AREA, SOIL_TEXT
SOIL_WATERf_p, SOIL_WATERf_ps	soil moisture frac [m3/m3]	PATCH_AREA, SOIL_WATER, SOIL_TEXT
leaf2_moisture	leaf2 moisture frac [m3/m3]	PATCH_AREA, SOIL_WATER, SOIL_TEXT, SNOW_MOIST, VEG_MOIST, CAN_RV
leaf2_temp	Similar to leaf2_moisture [m3/m3]	PATCH_AREA, SOIL_WATER, SOIL_TEXT, SNOW_MOIST, VEG_MOIST, CAN_RV

CATT

Field Name	*Description[units]*	*Model Variables*
CO	CO Concentration [ppb]	SCLP001
src1	Emission 1 [kg/m2/day]	scrsc001
src2	Emission 2 [kg/m2/day]	scrsc002
src3	Emission 3 [kg/m2/day]	scrsc003
src4	Emission 4 [kg/m2/day]	scrsc004
src5	Emission 5 [kg/m2/day]	scrsc005
src6	Emission 6 [kg/m2/day]	scrsc006
src7	Emission 7 [kg/m2/day]	scrsc007
src8	Emission 8 [kg/m2/day]	scrsc008
COstc	CO Conc. without conv. Transp [ppb]	SCLP002
COANT	CO Concentration ANTRO [ppb]	SCLP005
PM25	PM25 Concentration [ug/m3]	SCLP003, TOPT
PMINT	PM25 vert int [UG/M3]	SCLP003, TOPT
aot256	AOT 256nm [ ]	AOT
aot296	AOT 296nm [ ]	AOT
aot335	AOT 335nm [ ]	AOT
aot420	AOT 420nm [ ]	AOT
aot482	AOT 482nm [ ]	AOT
aot500	AOT 500nm [ ]	AOT
aot550	AOT 550nm [ ]	AOT
aot598	AOT 598nm [ ]	AOT
aot690	AOT 690nm [ ]	AOT
secog	GOES-8 ABBA CO emission [kg/m2/day]	DUM1

Field Name	*Description[units]*	*Model Variables*
secod	Duncan CO emission [kg/m2/day]	DUM1
secoant	Antropogenic CO emission [kg/m2/day]	DUM1
secoe	EDGAR CO emission [kg/m2/day]	DUM1
scco	Emitted CO mass [kg/(m2 day)]	QSC1
scpm25	Emitted PM25 mass [kg/(m2 day)]	QSC2
sccofe	Emitted CO FWB – EDGAR mass [kg/(m2 day)]	QSC3
sccoae	Emitted CO AWB – EDGAR mass [kg/(m2 day)]	QSC4
sccobbe	Emitted CO BB – EDGAR mass [kg/(m2 day)]	QSC5
sccod	Emitted CO Duncan mass [kg/(m2 day)]	QSC9
sccol	Emitted CO mass – logan [kg/(m2 day)]	QSC3
sccoant	Emitted CO mass – ANTRO [kg/(m2 day)]	QSC9
pwv	precipitable water vapor [cm]	RV, TOPT
CO2	CO2 Concentration [ppm]	SCLP004
TKUO	CO tend conc due conv trans [ppb/day]	DUM3
TKUOSH	CO tend conc due Shallow conv trans[ppb/day]	DUM8

Stilt – RAMS Coupling

Field Name	*Description[units]*	*Model Variables*
afxu	advect u flux [kg/m^2s]	AFXU
afxub	averaged adv u flux [kg/m^2s]	AFXUB
afxv	advect v flux [kg/m^2s]	AFXV
afxvb	averaged adv v flux [kg/m^2s]	AFXVB
afxw	advect w flux [kg/m^2s]	AFXW
afxwb	averaged adv W flux [kg/m^2s]	AFXWB

Field Name	*Description[units]*	*Model Variables*
sigw	sigma W [ ]	SIGW
sigwb	averaged sigma W [m/s]	SIGWB
tlb	averaged Lagr timescale [s]	TLB
tl	Lagr timescale [s]	TL
tkeb	average turb kinetic energy [m2/s2]	TKEPB
facup1	frac area cov up -deep [ ]	FACUP1
facup2	frac area cov up -shal [ ]	FACUP2
facdn1	frac area cov down -deep [ ]	FACDN1
cfxup1	conv up flux deep [kg/m^2s]	CFXUP1
cfxup2	conv up flux shallow[kg/m^2s]	CFXUP2
cfxdn1	conv down flux deep [kg/m^2s]	CFXDN1
dfxup1	deep conv flx up->env [kg/m^2s]	DFXUP1
efxup1	deep conv flx env->up [kg/m^2s]	EFXUP1
dfxdn1	deep conv flx env->down [kg/m^2s]	EFXDN1
dfxup2	shallow conv flx up->env [kg/m^2s]	DFXUP2
efxup2	shallow conv flx env -> up [kg/m^2s]	EFXUP2

GRELL cumulus scheme

Field Name	*Description[units]*	*Model Variables*
wdm1	Wet deposition mass tracer 1 [kg/m2]	wetdep001
wdm3	Wet deposition mass tracer 3 [kg/m2]	wetdep003
ierr	ierr [ ]	XIERR
ierrsh	ierr [ ]	XIERRSH
upmf	updraft mass flux [kg/(m^2 s)]	UPMF

Field Name	*Description[units]*	*Model Variables*
dnmf	downdraft mass flux [kg/(m^2 s)]	DNMF
shmf	shallow cum mass flux [kg/(m^2 s)]	UPMFSH
lsfth	DEEP forcing theta [K/day]	lsfth
lsfrt	DEEP forcing water vapor [g/kg/day]	lsfrt
lsfthsh	Shallow forcing theta [K/day]	LsfthSH
lsfrtsh	Shallow forcing water vapor [g/kg/day]	lsfrtSH
topcl	Cloud top [ ]	XKTOP
jmin	Down starts level [ ]	XJMIN
cprtint	vertint cp rt [kg/m2*s]	TOPT, RTSRC
xave	X_AVE [ ]	DUM5
xavec1	X_AVE Capmax [ ]	DUM5
xavec3	X_AVE Capmax [ ]	DUM5
xff0	XFF0 for deep [ ]	d2003
xff0sh	XFF0 for shallow [ ]	d2002
prgr1	precip closure 1 large cap [mm/h]	d3004
prgr2	precip closure 1 medium cap [mm/h]	d3004
prgr3	precip closure 1 low cap [mm/h]	d3004
prw1	precip closure 2 large cap [mm/h]	d3004
prw2	precip closure 2 medium cap [mm/h]	d3004
prw3	precip closure 2 low cap [mm/h]	d3004
prmc1	precip closure 3 large cap [mm/h]	d3004
prmc2	precip closure 3 medium cap [mm/h]	d3004
prmc3	precip closure 3 low cap [mm/h]	d3004
prst1	precip closure 4 large cap [mm/h]	d3004
prst2	precip closure 4 medium cap [mm/h]	d3004

Field Name	*Description[units]*	*Model Variables*
prst3	precip closure 4 low cap [mm/h]	d3004
pras1	precip closure 5 large cap [mm/h]	d3004
pras2	precip closure 5 medium cap [mm/h]	d3004
pras3	precip closure 5 low cap [mm/h]	d3004
xstd	X_STD [ ]	DUM5
xske	x_ske [ ]	DUM5
xcur	x_cur [ ]	DUM5
xmbgr	xmbgr [ ]	DUM5
xmbw	xmbmc [ ]	DUM5
xmbst	xmbst [ ]	DUM5
xmbas	xmbas [ ]	DUM5
prgr	prgr [ ]	DUM5
prw	prw [ ]	DUM5
prmc	prmc [ ]	DUM5
prst	prst [ ]	DUM5
pras	pras [ ]	DUM5
um	u mean [m/s]	DUM5
vm	v mean [m/s]	DUM5

TEB (Town Energy Budget)

Field Name	*Description[units]*	*Model Variables*
TROOF	Roof layers temperature [K]	T_ROOF
TROAD	Road layers temperature [K]	T_ROAD
TWALL	Wall layers temperature [K]	TWALL

TCANYON	Canyon Temperature [K]	T_CANYON
RCANYON	Canyon humidity [g/kg]	R_CANYON
TSROOF	Roof surface temperature [K]	TS_ROOF
TSROAD	Road surface temperature [K]	TS_ROOF
TSWALL	Wall surface temperature [K]	TS_WALL
LE_tr	Latent heat flux from traffic [W/m2]	LE_TRAFFIC
LE_in	Latent heat flux from industry [W/m2]	LE_INDUSTRY
H_tr	Sensible heat flux from traffic [W/m2]	H_TRAFFIC
H_in	Sensible heat flux from industry [W/m2]	H_INDUSTRY
PM25m3	PM25 Concentration [ug/m3]	PPM25, TOPT
NOm3	NO Concentration [ug/m3]	PNO, TOPT
NOppm	NO Concentration [ppmv]	PNO
NO2m3	NO2 Concentration [ug/m3]	PNO2, TOPT
NO2ppm	NO2 Concentration [ppmv]	PNO2
COm3	CO Concentration [ug/m3]	PCO, TOPT
COppm	CO Concentration [ppmv]	PCO
SO2	SO2 Concentration [ug/m3]	PSO2, TOPT
SO4	SO4 Concentration [ug/m3]	PSO4, TOPT
O3m3	O3 Concentration [ug/m3]	PO3, TOPT
O3ppm	O3 Concentration [ppmv]	PO3
VOCS	VOCS Concentration [ppmv]	PVOC
HO2	HO2 Concentration [ppmv]	PHO2
O3P	O3P Concentration [ppmv]	PO3P
O1D	O1D Concentration [ppmv]	PO1D
HO	HO Concentration [ppmv]	PHO

RO2	RO2 Concentration [ppmv]	RO2
RHCO	RHCO Concentration [ppmv]	PRHCO

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APENDIX C – Free Software Needs Free Documentation

The following article was written by Richard Stallman, founder of the GNU Project.

The biggest deficiency in the free software community today is not in the software--it is the lack of good free documentation that we can include with the free software. Many of our most important programs do not come with free reference manuals and free introductory texts. Documentation is an essential part of any software package; when an important free software package does not come with a free manual and a free tutorial that is a major gap. We have many such gaps today.

Consider Perl, for instance. The tutorial manuals that people normally use are non-free. How did this come about? Because the authors of those manuals published them with restrictive terms--no copying, no modification, source files not available--which exclude them from the free software world.

That wasn't the first time this sort of thing happened, and it was far from the last. Many times we have heard a GNU user eagerly describe a manual that he is writing, his intended contribution to the community, only to learn that he had ruined everything by signing a publication contract to make it non-free.

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